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Effect of Differentiated Instruction Modes on Secondary School Students' Academic Achievement in Chemistry In Aguata Education Zone

Onu, Anthonia Chidimma & Prof. Okigbo, Ebele Chinelo
Department of Science Education
Nnamdi Azikiwe University, Awka

Abstract: *The study determined the effect of differentiated instruction modes on secondary school students' academic achievement in chemistry. Two research questions and three null hypotheses guided the study. The study adopted quasi-experimental design. The population of the study consisted of 3,992 secondary school year two (SS2) students offering chemistry in Aguata Education Zone of Anambra State out of which 109 SS2 students were sampled using purposive and random sampling techniques. The instrument used for data was Chemistry Achievement Test (CAT) which was validated by lecturers in the Departments of Science Education, Educational Foundations and of Pure and Industrial Chemistry in Nnamdi Azikiwe University Awka. CAT reliability was established using Kuder Richardson Formula 20which yielded reliability coefficient of 0.89. The experimental group was taught using differentiated instruction while the control group was taught using conventional method. Research questions were answered using mean and standard deviation while the hypotheses were tested using analysis of covariance. The findings of the study revealed that there is significant difference between the mean achievement scores of students taught chemistry using differentiated instructional mode and conventional method in favour of differentiated instructional mode. Significant difference was observed between the mean achievement scores of male and female students taught chemistry using differentiated instructional mode. The study recommended among others that seminars and workshops should be organized by educational administrators and professional organisations such as STAN for chemistry teachers on how to use differentiated instructional modes in the chemistry classroom.*

Keywords: *differentiated, instruction, modes, chemistry*

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I. Introduction

The classroom environment is often composed of students manifesting different learning needs, academic focus, learning styles and learning at varied pace. This has continued to pose a challenge for classroom teachers who are faced with the problem of adopting strategies that can meet the individual or collective academic needs of the students. As our world diversifies, the need for curriculum and instructional changes becomes necessary. Therefore, the role of the teacher is gradually shifting from delivering knowledge to classroom students, to the teachers as facilitators of learning, often as a part of a team of teachers with differentiated roles (Bender, 2012). The teachers are not only faced with problems of instruction but also have to deal with the personal problems of the students such as their emotional stability, health, intellectual capacity, learning style, study-habit, interest, and pace of learning.

The teacher must have to deal with the students' problems if the teacher must accomplish the objectives of instruction and improve students' achievement. Academic achievement represents performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college, and university (Ricarda, Anja, Anne & Linder, 2015). According to Hattie (2009), academic achievement is a numerical score obtained in standardized assessments that often express or is indicative of individuals' intellectual capacity. In developed societies, academic achievement plays an important role in every person's life. Richardson, Charles and Rod (2012) noted that academic achievement as measured by the GPA (grade point average) or by standardized assessments designed for selection purpose such as the SAT (Scholastic Assessment Test) determines whether a student will have the opportunity to continue his or her education (example to attend a university). Academic achievement is an important area of interest to every science teacher including those in chemistry.

Chemistry is the study of properties, syntheses and uses of matter (Ababio, 2009). It deals with the study of laws that determine the structure of the universe with reference to the matter and energy in the universe. Chemistry plays a significant role in the technological growth of any nation as its techniques underpin the

understanding of other disciplines. Chemistry and its underlying areas plays significant role in the health, and technological industry, in military and environmental issues. Despite the importance of chemistry in scientific and technological development, the academic achievement of students in the subject has remained on average. This is most evident in the yearly examination reports on the WAEC performance of students in chemistry.

The West African Examination Council (WAEC) Chief Examiner's report in chemistry shows that less than 50% of the total students who sat for chemistry from 2007 to 2012 passed at credit and above in the WASSCE except in 2010 (see Appendix A, p. 81). From 2013 to 2016, the percentage number of students who passed at credit level and above was above 50%, yet, there has been a consistent decline is the percentage number of students who passed at credit level and above. Meanwhile, a review of students' achievement in SSCE in Chemistry in Nigeria from 2001 to 2013 confirmed the same trend of poor achievement (Achor & kalu, 2014). In addition, WAEC Chief Examiner's (2014-2017) general report on students' performance in chemistry shows that candidates' performance was generally not impressive and, among other observations, students are unable to answer questions relating to biogas and nitrogen; poor knowledge of solubility of gases such as nitrogen and its compound in water; poor knowledge of laboratory set-up and names of laboratory apparatus and test on solids instead of solutions. Teachers, parents and researchers among others have remained puzzled about the cause of the persistent poor achievement in chemistry.

The cause of the appalling chemistry achievements may be attributed to instructional method among the many other factors that have been implicated in literatures. The questions of which method or mix of methods that can improve chemistry achievement have left teachers and researchers wallowing in the innovation of teaching methods. However, none of these methods seem to take into account the individual differences that the students bring to the class when they come to learn chemistry. This may have left the efforts towards improving chemistry achievement futile.

While any group of students is likely to demonstrate considerable variation in their learning characteristics, the learning characteristics that are displayed by many students who perceive chemistry difficult and/or other learning disorders within the general education classroom are likely to further necessitate a variety of learning activities in most general education classes. As every veteran teacher realizes, students with learning challenges may be less engaged in the learning task, unable to cope with multiple instructions, and poorly organized in their thinking and work habits. When these deficits are coupled with severe academic deficits, the result can be very challenging for the chemistry teacher. Thus, these chemistry teachers are hungry for tactics and ideas that work for these challenging students. The differentiated instructional mode, while appropriate for virtually all general education classes, is particularly helpful to students with this array of learning challenges (Bender, 2008). The researcher is poised by the situation to investigate the effect of teaching modes that are tailored to chemistry students' needs such as differentiated instructional mode.

The concept of differentiated instructional mode of teaching was originally based on the need for teachers to differentiate instruction to meet the needs of diverse learners in the general education class (Carolan & Guinn, 2007). Okigbo & Chukwuma (2014) maintained that differentiated instructional mode was and is best conceptualized as a teacher's response to the diverse learning needs of students in the general education classes. Teachers must know the learners in the class, understanding not only such things about each learner as her learning abilities, her academic levels, and her individual learning styles and learning preferences but must also show a concern for each student by tailoring instruction to meet their unique needs. In creating the concept of differentiation, Tomlinson incorporated a wide range of recent research on how diverse students learn. The concept was primarily founded on Dr. Howard Gardner's concept of multiple intelligences, coupled with the more recent instructional suggestions emerging from the brain-compatible research literature (Gardner, 2006).

With this emphasis on diverse learning styles as a backdrop, Carolan and Guinn (2007) encouraged teachers to personalize the instructional activities in order to challenge students with a highly interactive, challenging, and interesting curriculum. Teachers were encouraged to consider students' unique learning styles and then differentiate the educational activities presented in the class to provide for those divergent learning styles. Therefore, differentiated instruction mode of instruction is a method of instruction in which the teachers proactively modify teaching methods, resources, learning activities, and student products to address the needs of individual students and small groups of students to maximize the learning opportunity for each student in the classroom in terms of achievement of learning (Miles, 2015).

The academic achievement of students is today affected by many factors. Some of these factors have been duly researched but little or no attention has been given to the different academic needs manifested by students in the classroom. Instructional processes are often not tailored with students' need in mind. Chemistry teachers often seek to fulfill the requirements of the curriculum in terms of making sure they cover the content areas of each term, give assignments and test and administer examination. Because student' needs are not often met in the course of instruction, they often lose attention and find it difficult to concentrate in learning such subject as chemistry which is often perceived by students as difficult and abstract. Take for instance, when teaching for instance, the chemistry concepts of "burning ice" and "sugarless sugar", the learning of these

concepts at the topic level already poses confusion for the students. To learn the concept better, a student among others may need the teacher to refresh his or her memory about the foundational knowledge that are basic to understanding such complex concepts.

It has been noted that at the secondary school level, students' find almost all aspects of chemistry difficult (Nwanze, Konyefa & Ezeanya, 2021). This is clearly shown in the yearly WAEC reports on chemistry as noted early. In learning organic chemistry, some students; find it difficult to give the International Union of Pure and Applied Chemistry (IUPAC) name of organic compound and inorganic chemistry, some students perceive some level of abstraction. In analytical chemistry, many students do not have access to the machines and analyzer or well-equipped laboratory that can foster their understanding and therefore, are often confused. In physical chemistry, students with poor background knowledge of mathematics or further mathematics especially in the area of differential calculus and integration, show high level confusion. For every aspect of chemistry, students depending on the level of their previous knowledge in chemistry, manifest individual needs that require attention by the teacher in the course of learning. A student may for instance need the teacher to explain the molecular formula of a compound through the bonding of the different elements, whereas another student may understand the concept based on the previous knowledge on valency. Even in the face of these needs, chemistry teachers adopt conventional method of teaching most of the times.

Conventional teaching method is a teacher-centred method of teaching where the teachers is seen as an authority who dishes out knowledge and information, with the students as receivers of information. In conventional classrooms, teachers are the center of activities and students would have to depend of them to learn. The conventional approach to learning may lead to students' passivity, however, it is useful for teaching large group of students. Conventional method of teaching also enables the teacher to cover large content area within a short period of time. In spite of these benefits, conventional method of teaching does not give room to meet the individual learning needs of the students. There is need therefore, to adopt innovative teaching methods that can enable the teacher to diversify learning in such a way that can meet the varied needs of the students including those needs that are particular to their gender.

Science learning including chemistry is sometimes gender stereotyped. In most chemistry classes in secondary schools, female students are often seen expressing fear in handling corrosive chemicals. When this fear engulfs their mind, they often express special learning needs for concepts that are related to such chemicals. When such needs are not met by the chemistry teachers, the female students may lose out in the lesson and achieve poorly in such areas. This may be one of the reasons why many female students opt out of chemistry and other chemistry related disciplines when furthering the future. The male students although may not show the same fear as the females, they yet manifest some level of academic needs peculiar to them either in terms of knowledge deficit in relation to what is to be learnt and confusion. These problems call for the chemistry teachers' attention to the individual needs of the students by differential instruction modes. The researcher is therefore poised to investigate, against this background, the effect of differentiated instruction modes on the academic achievement of chemistry students.

PURPOSE OF THE STUDY

The purpose of this study was to investigate effect of differentiated instruction modes on secondary school students' academic achievement in chemistry in Aguata Education Zone. Specifically, the study sought determine the:

1. Difference between the mean achievement scores of students taught chemistry using differentiated instructional modes and those taught using conventional method.
2. Difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes.
3. Interaction effect of teaching methods and gender on the achievement of students in chemistry.

RESEARCH QUESTIONS

The following research questions guided the study.

1. What is the difference between the mean achievement scores of students taught chemistry using differentiated instructional modes and those taught using conventional method?
2. What is the difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes?

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference between the mean achievement scores of students taught chemistry using differentiated instructional modes and those taught using conventional method.

2. There is no significant difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes.
3. There is no interaction effect of teaching method and gender on the achievement scores of students in chemistry.

II. Method

The study adopted a quasi-experimental design. Specifically, the pretest, post-test non-equivalent control group design was used. The area chosen for the study is Aguata Education Zone of Anambra State. The population of the study consisted 1, 217 (644 females and 573 males) senior secondary school year two (SS 2) students in 20 public secondary schools in Aguata Education Zone. Total sample size for the study was 109 SS2 students. This was composed using multi-stage sampling procedure. Only coeducational secondary schools were purposely chosen. This was to provide conditions where boys and girls work together under the same classroom condition and teaching. Two intact groups from two schools were sampled using simple random sampling technique (balloting with replacement). The names of the schools were listed on pieces of paper and picked at random. All the students offering chemistry in the two schools form the two intact groups. The two schools that were selected became the sampled schools. The two schools were assigned into experimental and control groups respectively using simple random sampling (toss of a coin). The experimental school had 57 students (26 males and 31 females) while the school for the control group had 52 students (23 males and 29 females).

The instrument for data collection was a Chemistry Achievement Test (CAT). This was drawn from a six week instructional units (research intervention) on chemistry covering the following topics: electronic structure and occurrence of nitrogen; laboratory and industrial preparation of nitrogen, physical and chemical properties of nitrogen and uses of nitrogen, Haber process of the preparation of ammonia, physical and chemical properties of ammonia and uses of ammonia. CAT was validated by lecturers from the Departments of Science Education, Educational Foundations and Pure and Industrial Chemistry all from Nnamdi Azikiwe University, Awka. The reliability of the CAT was established using the Kuder-Richardson Formula 20 (KR-20) to be 0.96.

The experiment was conducted in two phases. The first phase involved the training of the research assistant who is the regular chemistry teacher in the school to be used as experimental group. The second phase was the treatment. In each week, the students in the experimental groups were exposed to the selected content areas using differentiated instruction, while those in the control group were taught using conventional method. For the experiment, the first step was to conduct a pretest using the instrument developed for the content areas to be taught. An analysis of the pretest scores was done to classify students in the various categories for which instructions were differentiated. Students with range of scores that differ by ± 5 were categorized into groups of five students. For each student, learning progress inventory, a book where students progress in learning the concept is recorded, was developed for each student. As the lesson proceeds, the research monitored each student's progress with the aid of the teacher, and recommended when students may need to change group. During such change, a student may be grouped together with other students whose scores in the pretest differ by ± 20. Further monitoring involved students' achievement in class exercise, take home exercise, individual and group presentations, take home assignment, ability to compose a personal lesson note on the lesson and students involvement in peer review of lesson notes.

The researcher and the teacher needed to conduct individual lesson for any students who request additional classes to be able to understand the concept. These classes were conducted in the school laboratory during break times. In their groups, students were asked to build up individual lesson notes for each lesson, and then review the contents of their notes to synthesize the individual ideas. The group's note that emerged from the group review was used for group presentation.

In each group, students were also asked to construct at least 20 questions from the topic learnt and discuss them with their group members. Each student must provide answers to the questions he/she has set. The questions and the answers for each lesson were submitted via any member of the group to the teacher and then to the researcher who analyzed them for students' weaknesses, strength and learning progress. Findings from the evaluation questions of each student were recorded in each student's learning progress inventory. These activities must be conducted before the lesson in the first two periods for chemistry in the school chemistry timetable except for individual classes that was held for students who may need extra lessons on the concept.

In the last period, the teacher came to the classroom and taught the students. After the teaching in the classroom, the teacher gave the students class exercise on the concept taught in the school chemistry workbook. An immediate assessment of the students' learning will be conducted and marked. This formed the basis for regrouping and differentiating instruction for each student. The control group was taught by the school regular classroom teacher based on what method or mix of methods she wishes to adopt without any interference from the researcher. The content areas covered are as contained in the lesson plans for the experimental groups.

Data for the study was gathered by administering the instrument as pretest and posttest. The scores obtained from the test were collated by the teachers and given to the researcher. Data relating to the research

questions were analyzed using mean and standard deviation. Mean was used to determine the central or average scores of the students while standard deviation was used to show the spread of scores among the groups. The hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). The choice of ANCOVA is to eliminate the initial group difference that may exist among the participants. The decision rule was that whenever the probability (P-value) is less than 0.05, the null hypothesis was rejected, otherwise, the null hypothesis was not rejected.

III. Results

Research Question 1: What is the difference in the mean achievement scores of students taught chemistry using differentiated instructional modes (DIM) and those taught using conventional method (CM)?

Table 1: Mean Pretest and Posttest Achievement Scores of Students in Chemistry taught using Differentiated Instructional Mode (DIM) and Conventional Method

Source of Variation	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gain in Mean
DIM	57	23.33	5.99	79.26	2.69	55.93
CM	52	18.37	4.28	49.52	3.78	31.15

Table 1 shows that the students taught chemistry using DIM in the instructional delivery had pretest mean achievement score of 23.33 and posttest mean score of 79.26 with gain in mean score of 55.93 in chemistry, while those in the CM group had pretest mean score of 18.37 and posttest mean score of 49.52 with gain in mean 31.15. The CM group has higher spread of scores in the posttest than those in the DIM group. The use of DIM reduced the variation of scores in the posttest compared to the pretest.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes?

Table 2: Mean Pretest and Posttest Achievement Scores of Male and Female Students in Chemistry taught using DIM

Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gain in Mean
Male	26	22.69	5.22	80.88	2.77	58.19
Female	31	23.87	5.74	77.90	3.24	54.03

Table 2 shows that the male students taught chemistry using DIM had pretest mean achievement score of 22.69 and posttest mean score of 80.88 with gain in mean score of 58.19 in chemistry, while females had pretest mean achievement score of 23.87 and posttest mean score of 77.90 with gained mean 54.03. There was higher score variation among the females than among the males in the posttest.

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught chemistry using differentiated instructional modes and those taught using conventional method.

Table 3: ANCOVA on Significant Difference Between the Mean Achievement Scores of Students in Chemistry taught using DIM and Conventional Method

Source of variation	**SS**	**Df**	**MS**	**F**	**P-value**	**Decision**
Corrected Model	24057.381[a]	2	12028.690	532.147	.000	
Intercept	92193.722	1	92193.722	4078.633	.000	
Pretest	.001	1	.001	.000	.994	
Method	22795.760	1	22795.760	1008.480	.000	S
Error	2396.032	106	22.604			
Total	488019.000	109				
Corrected Total	26453.413	108				

Table 3 shows that at 0.05 level of significance, 1df numerator and 108 df denominator, the calculated F is 1008.480 with Pvalue of .000 which is less than 0.05. The null hypothesis was rejected. Therefore, there is significant difference in the mean achievement scores of students taught chemistry using differentiated instructional modes and those taught using conventional method. This was in favour of DIM group.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes.

Table 4: ANCOVA on Significant Difference between the Mean Achievement Scores of Male and Female Students in Chemistry taught using DIM

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	131.937[a]	2	65.968	3.235	.047	
Intercept	65462.170	1	65462.170	3210.340	.000	
Pretest	6.248	1	6.248	.306	.582	
Gender	122.327	1	122.327	5.999	.018	S
Error	1101.116	54	20.391			
Total	359344.000	57				
Corrected Total	1233.053	56				

Table 4 shows that at 0.05 level of significance, 1df numerator and 108 df denominator, the calculated F is 5.999 with Pvalue of .018 which is less than 0.05. The null hypothesis was rejected. Therefore, there is significant difference between the mean achievement scores of male and female students taught chemistry using differentiated instructional modes in favour of males.

Hypothesis 3: There is no interaction effect of teaching method and gender on the achievement scores of students in chemistry.

Table 5: ANCOVA on Interaction Effect of Teaching Methods and Gender on Students' Achievement in Chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	24236.240[a]	4	6059.060	284.210	.000
Intercept	90562.483	1	90562.483	4247.977	.000
Pretest	.236	1	.236	.011	.916
Method	22732.599	1	22732.599	1066.309	.000
Gender	169.076	1	169.076	7.931	.006
Method * Gender	5.683	1	5.683	.267	.607
Error	2217.173	104	21.319		
Total	488019.000	109			
Corrected Total	26453.413	108			

Table 5 shows that at 0.05 level of significance, 1df numerator and 108 df denominator, the calculated F is .267 with Pvalue of 0.607 which is greater than 0.05. Thus, the null hypothesis was not rejected. Therefore, there is no interaction effect of teaching method and gender on the achievement scores of students in chemistry.

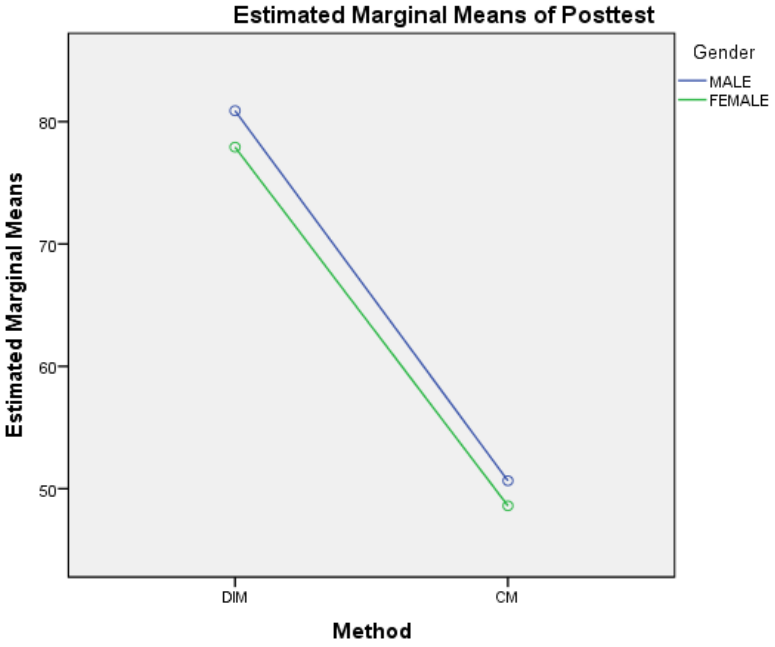

Figure 1: Plot of interaction effect of teaching method and gender on the achievement scores of students in chemistry

IV. Discussion

The study showed that there was significant difference in the mean achievement of students taught using differentiated instructional mode and those taught using conventional method in favour of differentiated instruction. The observed result can be attributed to the benefits accruing from the use of differentiated instructional mode. In differentiated instructional mode, the varied needs of the students are met by the teacher. By differentiating instruction, the teacher made learning very flexible through flexible grouping, ''respectful learning activities' and arrangement, and collaboration between teacher and students. Thus, by creating conducive environment where every student is given opportunity to have their academic needs met, students improved in their achievement more than those taught using conventional method.

Also, because the teacher differentiated instruction by creating groups where student can communicate their academic needs which is related to the learning objectives to one another, they had they needs met, not only by the teacher but also by their fellow students. The approach of meeting needs, also help the students to revisit the previous and requisite knowledge needed to learn the concepts taught. For instance, when teaching the structure of Nitrogen, some students found it difficult to understand the bonding in nitrogen compounds and because of such need, the teacher revisited the concepts of valency and oxidation number. With such activities, students properly conceptualized what was taught.

The finding of the study is in line with the findings of Patricia (2007) that differentiated instruction play vital and significant role in students' achievement. The finding of the study also support that of Michelle and Robert (2010) that there was significant difference between an experimental group taught using differentiated instruction and the control group in favour of the experimental group. The finding of Kimberly (2012) that there were significant differences between students who received differentiated instruction compared to students who were instructed using traditional lecture-based strategies, also supports the finding of the study. The finding of the study lend credence to the finding of Osuafor and Okigbo (2013) that significant difference existed between the achievement of students taught biology with differentiated instruction and those taught with conventional method in favour of former group.

The findings of the study further showed that there was significant difference between the mean achievement scores of male and female students taught using differentiated instructional mode. There was also no significant interaction effect of teaching methods and gender on students' achievement in chemistry. The finding of the study is in line with the findings of Olumide (2013) the mean post-test of the male and female in the computer simulation group differed significantly. The findings of the study is also in line with the findings of Abungu, Okere and Wachanga (2014) there was statistically significant difference between the mean scores of boys and girls in experimental groups.

V. Conclusion

The study concludes that adopting the use of differentiated instructional mode as a method of teaching chemistry effectively improves achievement more than conventional method. The use of differentiated instruction also helps students to meet their academic needs.

VI. Recommendations

The following recommendations are made in the light of the findings of the study:

1. Seminars and workshops should be organized by educational administrators for chemistry teachers on how to use differentiated instructional modes in the chemistry classroom.
2. Effort should be made by chemistry teachers to learn and master how to plan instructional plans using differentiated instructional modes.
3. In differentiating instructions for students, the teachers should endeavor to carry all students along and meet their needs irrespective of gender.

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